

## Research Article

### Improvised Energy Meter Supporting Wireless Data Transfer

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**Abstract:** The purpose of the study is to design a prototype model of an energy meter which has the ability of wireless data transfer such as sending emails and SMS. In the current energy monitoring scenario, manual energy meter monitoring is a cumbersome and tedious process for the electricity boards. It involves huge manpower and higher expenditure for a simple task. Manual energy meter monitoring is highly erroneous and amounts to great losses for both the consumers and the electricity boards. In this conventional technique, losing the bills and delay in the arrival of the official to note down the reading are common affairs. Complete digitalization of bill delivery and transaction processes eliminates such uneventful circumstances. The manual reading method is inefficient to meet the raising power demands. The invention described here has the potential to wipe of manual energy meter reading from the scene and replace it with a sophisticated automated system facilitating remote monitoring of energy consumption. In this proposed system, the Raspberry Pi performs all the essential functions of a microcontroller and supports features like sending emails and SMS with the aid of Wi-Fi dongle and GSM modem. This automated system enables continuous monitoring of energy consumption.

**Keywords:** Analog to Digital Converter (ADC), Global System Monitoring (GSM), raspberry pi, Short Message Service (SMS), Simple Mail Transfer Protocol (SMTP)

## INTRODUCTION

Electricity forms an integral part of our life and we consume electricity round the clock. Electric power has paved the way for innumerable inventions and has formed the backbone of the human civilization. So there is a need for a more systematic monitoring system to measure the power consumed. We use an energy meter for this purpose. In the manual meter reading system, the process is gargantuan, as an electricity board official has to visit each consumer's residence to record the meter reading. Further billing process is a Herculean task. Our innovation unfolds a new technology in the energy meter monitoring arena, utilizing the Raspberry Pi. With this innovation, it is possible to monitor the energy consumption and it also facilitates wireless communication through Wi-Fi and GSM modules. The software written in Python platform and loaded in the Raspberry Pi calculates the bill amount and sends the payment details to the users and electricity board through SMS and email by GSM module and accessing Wi-Fi, respectively. It is more accurate and reliable and is capable of preventing miscreants from manipulating the energy meter.

As depicted by Abhinandan *et al.* (2012), this technology is highly advanced and supports automated

meter reading even in remote areas. The main objective of this research is to reduce the wastage of human resources for meter reading and thereby enabling computerized collection and compilation of energy consumption data. This study presents an improvised solution for the energy providers to collect the energy consumption data from the consumers end with wireless data transfer. The objectives of this study were to measure current, voltage and power factor, thereby, calculating the amount of energy consumed. Further efforts were also taken to solve real life problems and to make this project industrially viable. This project makes use of intricate coding and electrical and electronic components. This energy meter will make the tasks of daily man easy. The overall set up of this project is shown in Fig. 1.

## MATERIALS AND METHODS

Research in this area brought to the fore a plethora of energy measuring devices available. These devices record the power consumed in terms of Kilowatt hour and the further billing processes based on the tariff scale take place in the electricity board. Several systems have been devised for automatic energy monitoring

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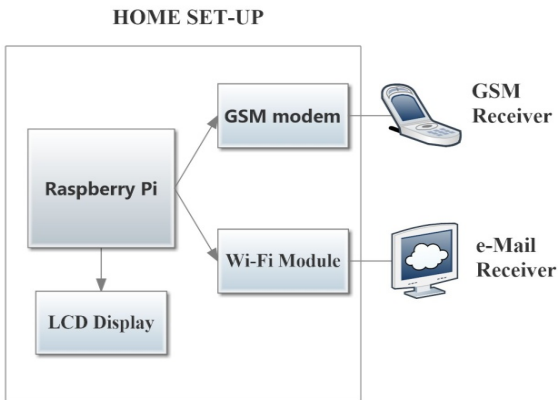


Fig. 1: Overall view



Fig. 2: Raspberry pi



Fig. 3: GSM module

which are wire based and wireless. In the present, GSM communication is the best method for wireless transmission and there is an increasing demand for systems based on it. It is a tool of paramount importance for sending SMS. Here, we have followed the tariff scale of Tamil Nadu electricity board. Kothari *et al.* (2012) and Bhupendra (2013) explains the basics of the embedded systems.

**The raspberry pi:** This system utilizes a credit card sized computing device called the Raspberry Pi, (Matt and Shawn, 2012), (Fig. 2), equipped with a GSM modem and a Wi-Fi module. Here, the Raspberry pi functionally performs the task of the microcontroller in the digital energy meter. The Raspberry Pi consists of several peripherals like USB ports, HDMI ports, slot for memory card and Ethernet port. The software devised can be loaded into the Raspberry Pi through a memory card. This performs the entire task of computing the power consumed and transmitting the computed values.

**GSM module:** GSM communication technology used here plays the role of informing the consumers



Fig. 4: Wi-Fi dongle

regarding their power usage and their tariff platform. For this purpose, GSM modem (Fig. 3), is connected with the Raspberry Pi which indicates the time frame for the GSM to send the SMS. The consumer will receive the SMS which informs the power consumed and tariff details via GSM modem.

**Wi-Fi module:** Wi-Fi signals can be detected by the Raspberry Pi, by inserting a Wi-Fi module into one of its USB ports. Wi-Fi signals are picked up by the module from a hotspot. The software sends the mail regarding the power consumption to the centralized server of the electricity board weekly, monthly or on request. The Raspberry Pi should have internet access to send the e-mail. This can be supported by Wi-Fi or a wired network that makes use of the Ethernet port of the Raspberry Pi. Figure 4 shows a Wi-Fi Dongle.

## ARCHITECTURE AND DISCUSSION

This single phase energy measuring device is designed with the help of a Raspberry Pi, GSM modem and a Wi-Fi module. The internal architecture of the system (Feng and Percy, 2013) is shown in the Fig. 5. Power measurement takes place with the help of a current sensor and a potential sensor. Current sensor detects the current flowing through the load and the potential sensor detects the voltage at which the load is being operated (Sawhney, 1987). These sensors give the output in analog form. The amplitude of the waveform as indicated by the sensors differs from that of the original waveform. However, these sensors duplicate the wave shape of the signal input. This analog signal has to be converted to digital form in order to feed it into the Raspberry Pi, as the Raspberry Pi detects only digital signals.

The analog outputs of the current sensor and the potential sensor are given as inputs to the Analog to Digital Converter (ADC). The input signal gets quantized and a continuous discrete digital signal is being produced. This converted digital value is delivered to the Raspberry Pi through the GPIO pins and further computations are done by using the software devised.

Raspberry pi has 26 pins in total of which three are power supply pins; six are DNC (Do Not Connect) pins and the remaining seventeen are GPIO pins. The

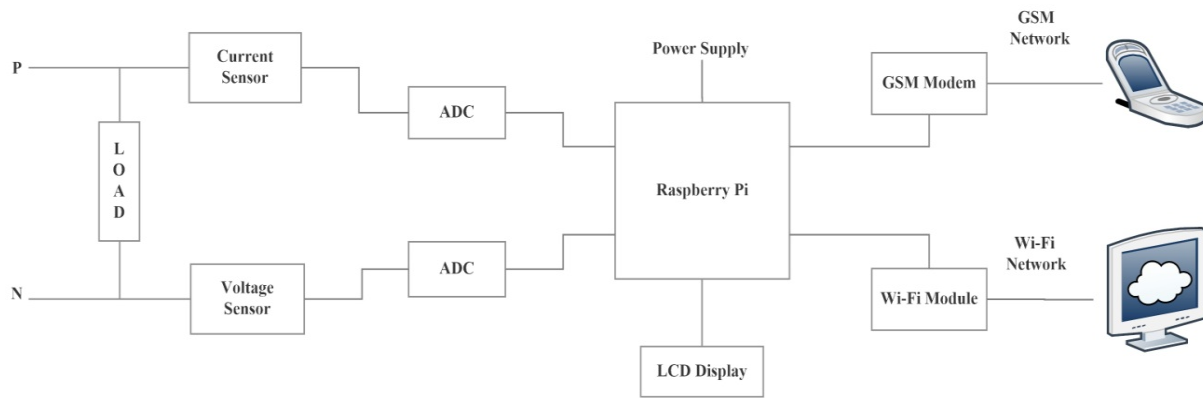


Fig. 5: Internal architecture

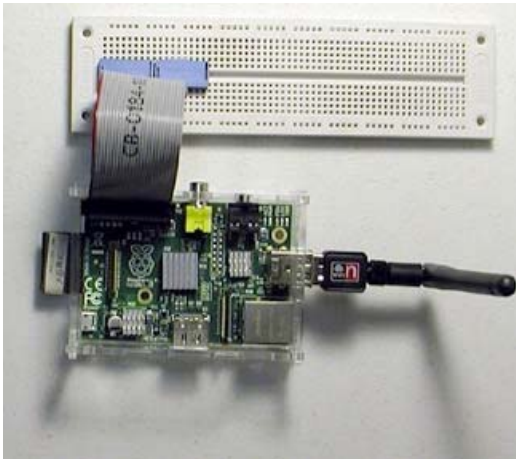


Fig. 6: GPIO pin extension circuit

seventeen GPIO pins are insufficient for our system. So there occurs a need for pin extension. We have used a 16 pin MCP23017 for this purpose. This circuit is shown in Fig. 6.

The Raspberry Pi is supplied with power from AC to DC adapter. It can also be powered from direct supply through a voltage regulator. This regulator converts the 12V supply from the adapter to the acceptable 3.3V. The software is built under Python platform which is user-friendly. The instantaneous current and voltage values are being measured and their product gives the electric power consumed by the load. This reading is displayed in the LCD display in terms of KWh. Power factor, date and time will also be displayed. The block diagram of the energy meter is shown in Fig. 5.

Real time clock is an integrated circuit that maintains the current time and date. As this software relies on time, a real time clock is employed with DS1307. This is used because of its low power consumption and has high accuracy factor. This is depicted in Fig. 7.

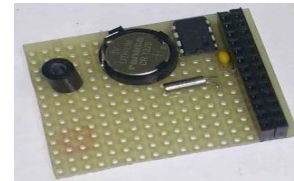


Fig. 7: Prototype real time clock

The functionality of the Raspberry Pi is advanced with GSM modem and Wi-Fi module. The GSM modem connected with the raspberry pi facilitates data transmission from the meter to the consumer's cell phones. Since it occupies a vast position in the wireless communication arena it can be used to extend these services to a large population. The power consumed is transferred to the consumer on a recommended interval of time.

Wi-Fi module allows for exchange of data with the electricity board. The data sent is composed of the amount of power consumed, the billing details at a regular interval of time. Wi-Fi module can connect to the internet through a wireless network access point. It also allows cheaper access to Wi-Fi. Initially, the Raspberry Pi is configured with static IP address using DHCP (Dynamic Host Configuration Protocol), to ensure that it accesses the same Wi-Fi signal.

Figure 8 shows the algorithm of the digital energy meter. Measurement of power factor is one of the laborious tasks. ADC subsystem and timer subsystem have been used for this process. Whenever the voltage crosses zero the timer starts and whenever the current crosses zero from positive to negative the timer is stopped. This difference in time is used for calculating the angle of deviation. The real Power (P) is given by  $P = VI\cos\Phi$  where  $\Phi$  is the phase angle between Voltage (V) and current (I). The total Energy (E) consumed by the load is given by  $E = \text{Power} \times \text{time}$ . The energy is expressed in terms of KWh (Kilo Watt hour). The digital values of voltage, current, power factor and the energy consumed are displayed on the LCD screen.

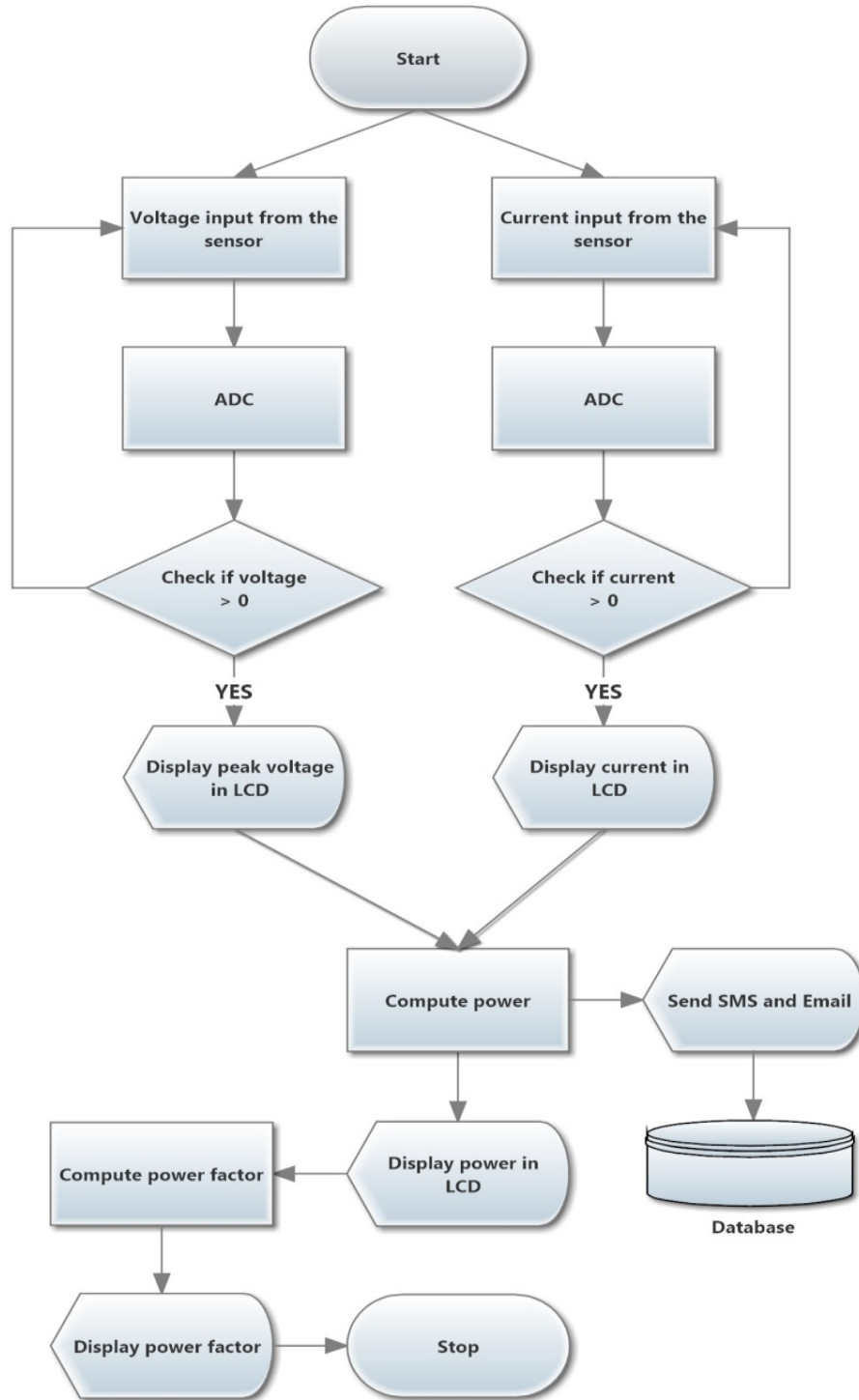


Fig. 8: Algorithm

The software designed with python here supports technically in predicting the energy consumption and transmitting the required details to the consumer and the supplier of electricity via SMS and E-mail automatically. Figure 8 shows the algorithm of our software. SMTP (Simple Mail Transfer Protocol) and E-mail modules are used for mailing facility (Praveen,

2011). The mail id of the consumer and the supplier are indicated in the program. The consumer's mobile number is also accessed for sending SMS to the consumer about the energy consumed and billing details. This type of computerized monitoring enables a better way of identifying the energy consumption.

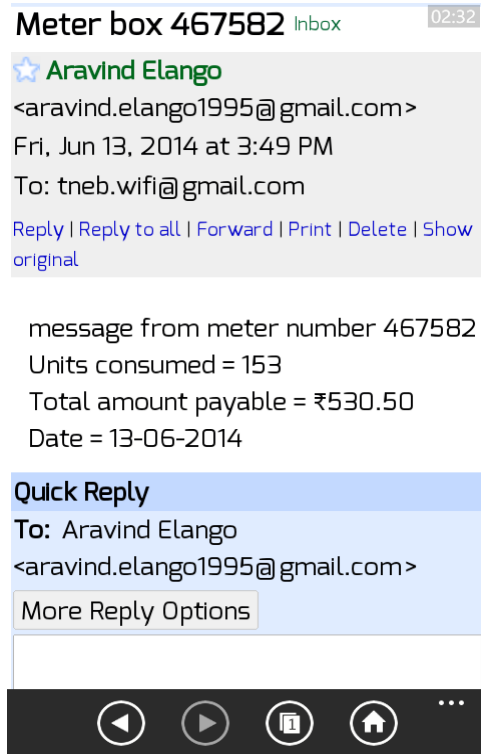


Fig. 9: Screenshot of email

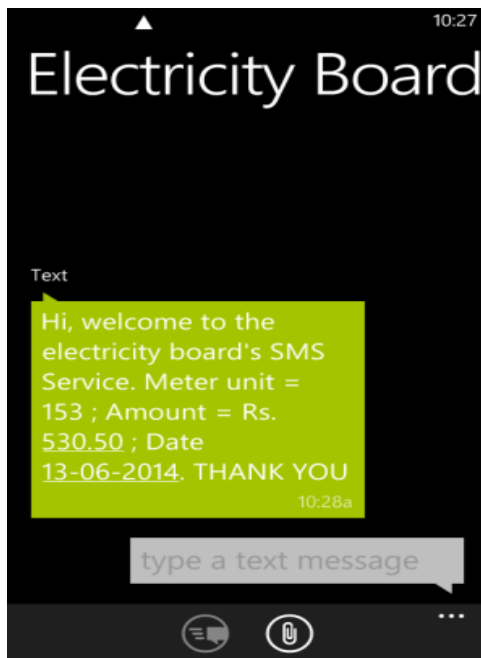


Fig. 10: Screenshot of SMS received

This cutting-edge development in wireless energy monitoring is highly capable of suiting it to any other load conditions other than house hold with a small adjustment (Ananth *et al.*, 2008). The aim of this project is to replace all the inefficient analog meters with efficient digitalized meters as the digital data is

easier for calculations and programming processes. The process of billing is made simple by just altering the codes. The programming language chosen here is Python which is simple to handle. With the above factors in mind, a prototype model has been successfully developed. This single phase digital energy meter formulated with the Raspberry Pi measures the voltage, current, energy and power factor and transmits these data wirelessly through a GSM modem and Wi-Fi module to the consumers and the suppliers through SMS and e-mail. Figure 9 and 10 shows the email and the SMS generated by the energy meter, respectively.

This energy meter fits for both domestic and industrial applications. In the domestic consumption, power factor is not of major concern since majority of the loads are resistive and inductive. The tariff and billing process are made with KWh rating. In industrial applications, the power factor changes continuously because of reactive power along with real power since the applications are capacitive. Our energy meter is a more reliable and cheaper alternative.

**Technical hindrances:** Since the Raspberry Pi does not have a built-in real time clock, there is a need to design a separate real time clock out of the Raspberry Pi. Due to this there was also a need to extend the GPIO pins as the built-in GPIO pins of Raspberry Pi was insufficient. The initial configuration of Raspberry Pi is a complicated task and it is difficult for beginners.

## CONCLUSION

Various electronic meters have been developed and are still being developed. However the use of the Raspberry Pi as an energy meter provides numerous advantages over other methods that have been already developed. The proposed system provides easy access to Wi-Fi to send mail whereas there is no USB port in the microcontroller of the energy meter. It is highly effective in the sense that it is accurate and time consuming. Also reduction in the price of computing devices makes this system even more adoptable. It improves the cost and quality as it reduces theft and corruption on the electricity distribution network. In the present era where internet is easily available and the use of cost efficient transmission of readings through GSM is advantageous, this energy monitoring system plays a definite role in making the tedious task of manual energy monitoring system easier. In lieu of increasing electricity demand, there also arises a need for an efficient energy monitoring system. Thus this system thus provides an efficient and precise solution for the same.

## RECOMMENDATIONS

The devised system can be further extended by suitably making small modifications. Some of the modifications that can be made are:

- Pre-paid energy meters require the consumers to pay the electricity bill before consumption
- Disconnection of power supply in case the bills are not paid in time
- Monitoring the individual power consumptions (e.g., power consumed by air conditioner alone)
- Ability to disconnect power supply for a particular item (e.g., when you reach the monthly limit for a/c)

#### REFERENCES

- Abhinandan, J., K. Dilip and K. Jyoti, 2012. Design and development of GSM based energy meter. *Int. J. Comput. Appl.*, 47(12).
- Ananth, N., P. Bharath, K.V.J. Prakash and S. Vijetha, 2008. Wireless automated digital energy meter. *Proceeding of the IEEE International Conference on Sustainable Energy Technologies (ICSET, 2008)*, Singapore, pp: 564-567.
- Bhupendra, S.C., 2013. *Microcontrollers and its Applications*. 1st Edn., SIPL, New Delhi, India.
- Feng, H. and Y. Percy, 2013. Implementation of a single-phase electronic watt-hour meter using the MSP430AFE2xx. *Application Report SLAA494A*, Texas Instruments Inc., Dallas.
- Kothari, D.P., K.V. Shriram, R.M.D. Sundaram and N. Murali, 2012. *Embedded Systems*. 1st Edn., New Age Publications, New Delhi, India.
- Matt, R. and W. Shawn, 2012. *Getting Started with Raspberry Pi*. 1st Edn., Shroff Publishers and Distributors Pvt. Ltd., Bangalore, India.
- Praveen, M.P., 2011. KSEB to Introduce SMS-based Fault Maintenance System. *The Hindu News*, Retrieved from: <http://www.hindu.com> (Accessed on: June 26, 2011).
- Sawhney, A.K., 1987. *A Course in Electrical and Electronic Measurements and Instrumentation*. 5th Edn., Dhanpat Rai and Sons, Delhi, India.